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Fugitive Emission Control for the APE 1236 Deactivation Furnace

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ABSTRACT: The U.S. Army Ammunition Peculiar Equipment (APE) program currently has several operating rotary kiln 1236 ammunition deactivation furnaces located throughout the United States. These furnaces must comply with the fugitive emission requirement of the Hazardous Waste Combustor National Emission Standard for Hazardous Air Pollutants. During operations, emissions from ammunition detonation may escape through openings. An enclosure was constructed over the feed, furnace, and discharge areas of the APE 1236 furnace at Tooele Army Depot (TEAD) to contain fugitive emissions. A monitoring system was designed and installed to measure and record the effects of pressure fluctuations and airflows at the enclosure walls. The system was effective at detecting a detonation and recording sensor data for a specified period of time surrounding that detonation. A demonstrated average negative differential pressure (DP) between the inside and outside of the enclosure represents fugitive emission control. The enclosure was originally not shown to maintain a negative DP, so it was sealed with polyurethane to close openings. Further testing showed a lower but still positive pressure. Permanent sealing of the dampers and installation of a sealing overhead door brought the average pressure to negative and the TEAD furnace into compliance with fugitive emissions requirements.

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Conversion Factors

Non-SI* units of measurement used in this report can be converted to SI units as follows:

Multiply	By	To Obtain
cubic feet	0.02831685	cubic meters
degrees Fahrenheit	$(5/9) \times (^\circ\text{F} - 32)$	degrees Celsius
feet	0.3048	meters
miles (U.S. statute)	1.609347	Kilometers
pounds (force) per square inch	6.894757	kilopascals

* *Système International d'Unités* ("International System of Measurement"), commonly known as the "metric system."

Glossary

Differential pressure

The difference in pressure between two points of a system.

Absolute pressure

The pressure above a complete vacuum or gauge pressure plus the atmospheric pressure.

Anemometer

A wind speed measurement instrument that comes in five major types: rotational, pressure tube, deflection, thermoelectric, and ultrasonic and LASER Doppler.

Pressure transducer

An instrument that detects a pressure and produces an electrical signal related to that pressure.

Acronyms

APE	Ammunition Peculiar Equipment
CD	compact disk
CERL	Construction Engineering Research Laboratory
DAS	Data Acquisition System
DC	direct current
DP	differential pressure
EPA	U.S. Environmental Protection Agency
EQT	Environmental Quality Technology
ERDC	U.S. Army Engineer Research and Development Center
HAP	Hazardous Air Pollutant
HCB	hexachlorabenzene
HWC	Hazardous Waste Combustor
Hz	hertz
I/O	input/output
in.w.c.	inches of water column
mA	milliampere
MACT	Maximum Achievable Control Technology
mph	miles per hour
ms	millisecond
MSE-TA	MSE Technology Applications, Inc.
NESHAP	National Emission Standard for Hazardous Air Pollutants
NI	National Instruments Corporation
RCRA	Resource Conservation and Recovery Act
TEAD	Tooele Army Depot
UPS	uninterrupted power supply

Preface

This study was conducted for Headquarters, Department of the Army under Program Element 063728A, “Environmental Technology Demonstration”; Project 002, “Environmental Compliance Technology”; Work Unit CNE-B091, “Hazardous Air Pollutants Technology Demonstrations,” and for the Facility Modernization and Sustainability Group Program. The CERL technical reviewer was Hany Zaghloul, Program Manager for Environmental Compliance, Office of the Technical Director.

The work was performed by the Environmental Process Branch (CN-E) of the Installations Division (CN), Construction Engineering Research Laboratory (CERL). The CERL Principal Investigator was Dr. K. James Hay. Part of this work was performed by MSE Technology Applications, Inc. under DE-AC09-96EW96405 and by Tooele Army Depot. Dr. Stephen W. Maloney is Acting Chief, CN-E, and Dr. John T. Bandy is Chief, CN. Martin J. Savoie is the Technical Director for the Installations business area. The CERL Deputy Director is Dr. Kirankumar V. Topudurti, and the CERL Director is Dr. Ilker Adiguzel.

CERL is an element of the U.S. Army Engineer Research and Development Center (ERDC), U.S. Army Corps of Engineers. The Commander and Executive Director of ERDC is COL Richard B. Jenkins. The Director of ERDC is Dr. James R. Houston.

1 Introduction

Background

The U.S. Army Ammunition Peculiar Equipment (APE) program currently has several operating rotary kiln 1236 ammunition deactivation furnaces located throughout the United States. These furnaces must comply with the Hazardous Waste Combustor (HWC) National Emission Standard for Hazardous Air Pollutants (NESHAP, 70FR59401). This NESHAP primarily regulates stack emissions from the furnace; however, one requirement addresses fugitive emissions. This is described under the Federal Register, Volume 64, Requirements for Combustion System Leaks and Title 40, Code of Federal Regulations, Section 63.1203 (a), March 2, 2002, Amendment 8, which mandates the mission limits for discharge into the atmosphere for existing sources. Failure to meet this fugitive emissions requirement could halt the operation of a regulated furnace.

The current configuration of the APE 1236 Deactivation Furnace has a fugitive emissions shroud around the retort sections of the furnace. Since the mission of the APE 1236 is to incinerate ammunition items, some detonations are large enough to generate pressures great enough to expel fugitive emissions past the shroud and into the feed and discharge areas. Fugitive emissions also may come from processed items coming out of the discharge area onto the discharge conveyor and into waste collection drums. A solution is needed to control these emissions.

Objective

The objective of this research was to design, develop, and test an enclosure for the APE 1236 Deactivation Furnace that would control all fugitive emissions generated by detonations and smoking items discharged from the furnace. The exit criterion for this technology application was to meet the fugitive emission requirement of the HWC NESHAP and be accepted by the respective state regulatory agency.

Approach

An enclosure was designed and installed at the APE 1236 Deactivation Furnace at Tooele Army Depot (TEAD) in Utah to encapsulate a large accumulating volume of Hazardous Air Pollutant (HAP) emissions from the feed, furnace, and discharge area and vent this volume through the air pollution control system. Design of the system involved research and engineering to maintain the proper pressure criteria during furnace operation and to ensure no leakage of emissions. A monitoring system was designed and installed as part of the enclosure, which included ventilation ducts and complete pressure and air flow monitoring to evaluate the enclosure's performance. The monitoring system was used during testing to determine what modifications were necessary to prevent fugitive emissions. A slightly negative pressure maintained in the enclosure would signify successful fugitive emission control.

Mode of Technology Transfer

This technology was developed and demonstrated through the U.S. Army Engineer Research and Development Center, Construction Engineering Research Laboratory (ERDC/CERL) HAP Project and the ERDC/CERL Waste Minimization and Pollution Prevention Program. The HAP Project is part of the Army Environmental Quality Technology (EQT) Program. As part of the EQT process, a technology transfer plan is being developed by the Army Environmental Center for this and other qualified technologies under the HAP Project. This technology was successfully implemented into the field through the work discussed in this report and is available for transfer to other military furnace applications.

This report will be made accessible through the World Wide Web (WWW) at URL:
<http://www.cecer.army.mil>

2 Fugitive Emission Enclosure Design and Installation

The fugitive emission enclosure was designed for the APE 1236 demilitarization furnace at TEAD to control all fugitive emission generated by detonations in the furnace and smoking items discharged from the furnace. This chapter discusses the design and installation of this enclosure.

Enclosure Design

The production facility at TEAD consists of three zones: the control/feeder room (zone 1), the production furnace area (zone 2), and the collection room (zone 3). The production furnace originally stood in open air enclosed by four-side protection walls. The thick concrete protection walls are between zones 1 and 2 and between zones 2 and 3. The other protection walls are on the sides of zone 2, so that zone 2 is surrounded.

Due to the exhaust fan, the exhaust outlet from the furnace was in negative gauge pressure. Therefore, during typical operation (e.g., burning small caliber ammunition), the harmful exhaust gas from the furnace was sucked into the exhaust duct that is connected to the air pollution control system. Burning a large amount of explosive (e.g., an artillery shell), however, can cause the instantaneous pressure inside the furnace to exceed the atmospheric pressure. In this situation, harmful gases can escape through the openings of the furnace vessel (input conveyor hopper, output conveyor hopper, and inspection hole) and be released to the atmosphere. Any escaping exhaust gas is considered fugitive. Figure 1 shows the input conveyor opening, and Figure 2 shows the output conveyor opening.

Since the furnace openings (input and output conveyor hoppers) cannot be sealed, an external envelope surrounding the furnace is required to prevent the fugitive gas from escaping into the atmosphere. Whereas the feed room with the input conveyor is already enclosed and needs to be kept at conditions suitable for workers, the output conveyor can be inside this envelope. In addition, enclosure of the discharge area can prevent the escape of smoke from discharged items. The fugitive gas released into the envelope would be pulled back into the furnace supply air stream

and leave the envelope through the exhaust duct, thereby passing through the air pollution control device before being released into the atmosphere. The primary objective of the design was to assure that fugitive gases were prevented from leaking out of the enclosure, so the pressure inside the enclosure must be maintained below the atmospheric pressure and the pressure inside the feed room.

The size of the enclosure was determined primarily by the need to enclose zones 2 and 3 entirely. Zone 2 includes the afterburner, which is positioned at an elevated height next to the furnace (shown in Figure 3). Figure 4 shows an overview of the furnace area with the afterburner above the furnace before the enclosure was installed. The resulting size was determined to be more than adequate to contain the forced ejections of fugitive emissions from the furnace.

The enclosure was designed as a standard size (80-feet long by 24-feet wide by 20-feet tall) metal structure that encapsulates the furnace and discharge areas of the furnace operation. The feed area is already enclosed. The new structure was designed to attach directly to the South wall of the feed area building where the input conveyor exits. The structure was designed with several openings: single-door access on each side, except the North side; a double-door access centered on the West side; a large overhead door for removing waste from the discharge area on the South side; and two dampers near the South end to allow makeup air to enter the enclosure. These dampers were free-hinged to allow fresh air to enter only during conditions where the pressure inside the enclosure is less than outside. Figure 5 shows the original enclosure design footprint with respect to the existing furnace setup and air pollution control.

Enclosure Installation

Figures 6 through 9 show the installed enclosure before the dampers and monitoring system were installed. Figure 10 shows the west side of the enclosure after the dampers and monitoring system were installed.

It was understood that, when the enclosure was installed, the structure would have minor leaks. This was thought to be an advantage because there was a concern that not enough makeup ventilation would be provided to offset the expected 2,750 cubic feet per minute of exhausted air. After installation, however, it was determined that the enclosure was not under negative pressure and that lack of air supply was not an issue. As will be discussed in following chapters, several efforts were made to restrict the air intake and gain a negative pressure condition.

Another design issue confronted after installing the system was that the radiant and convective heat from the retort and ducting caused the air inside the enclosure to be too hot (140–160 °F). A heat shield was originally placed over the retort sections before the enclosure was installed to help vent the heat back to the combustion fan. However, this modification did not prevent the temperature inside the enclosure from being higher than desired (<140 °F).



Figure 1. Input conveyor to furnace.



Figure 2. Output conveyor from furnace.



Figure 3. Furnace with afterburner support platform above, looking toward feed room.



Figure 4. Furnace area overview with air pollution control system.

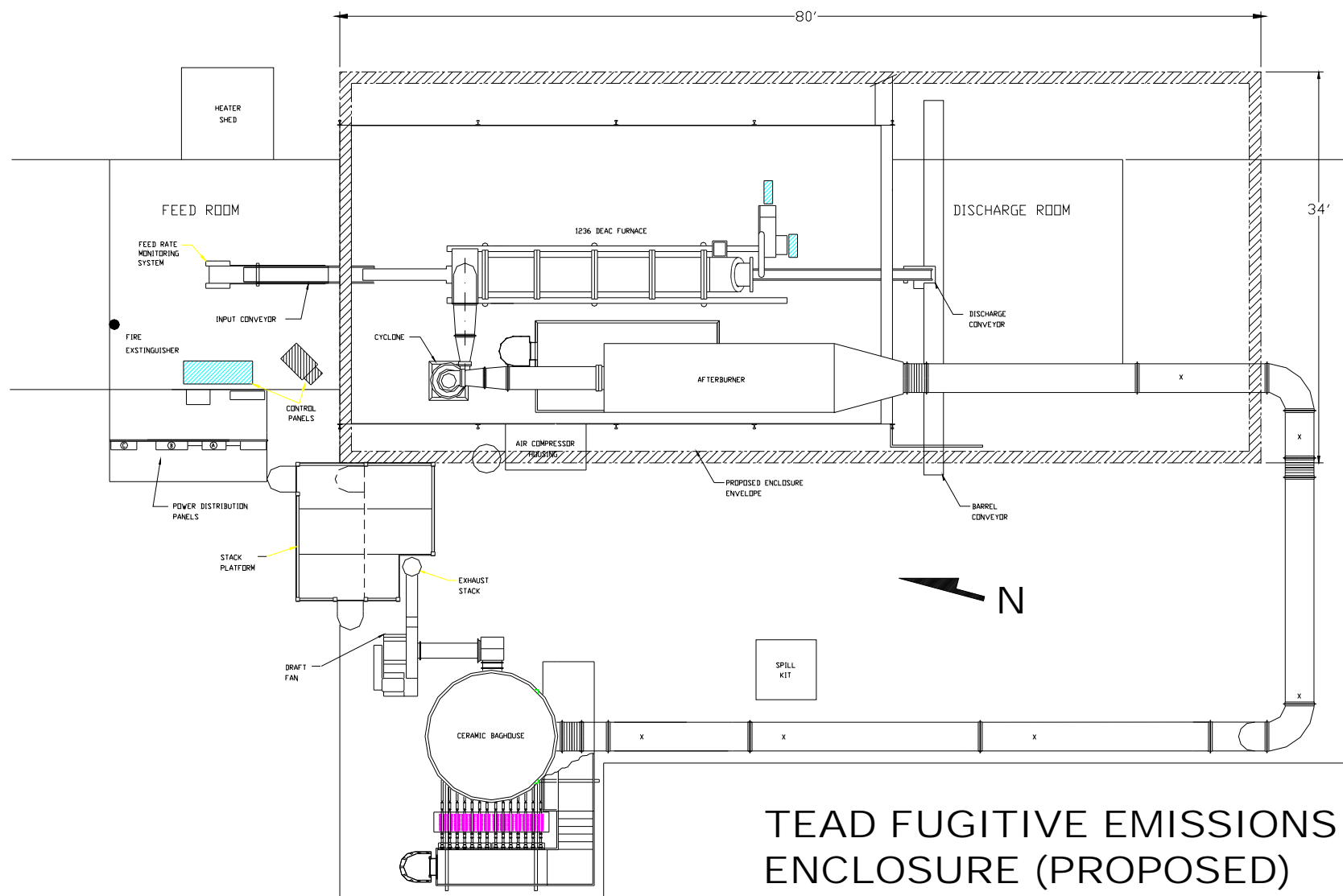


Figure 5. Original proposed enclosure footprint.



Figure 6. Outside view of North side of enclosure.



Figure 7. West outside wall of enclosure.



Figure 8. Inside enclosure – feed end.



Figure 9. Inside enclosure – discharge end.



Figure 10. West side of enclosure with air pollution control system and (white) multi-metal continuous emission monitor shack.

3 Monitoring System

The monitoring system assists in determining the escape of fugitive emissions into areas of the enclosure by measuring the propagation of pressure changes and flows during detonations, and sending this information to a data acquisition system. The design, procurement, and installation were completed 26 September 2003. This chapter describes the equipment and layout of the system.

Monitoring System Equipment

Pressure Monitoring Equipment

The Validyne DP 45 sensor system was chosen to measure the high speed small DP fluctuations on the walls of the enclosure. The sensor system specifications are:

- DP range of +/- 0.8 inches of water column (in.w.c.);
- less than a 1-millisecond (ms) response time;
- accuracy of +/-0.5 percent full-scale including the effects of linearity, hysteresis, and repeatability; and
- interface electronics included to provide 4-20 milliamper (mA) current interface to the data acquisition system (DAS; Validyne CD 16-A-1-E Carrier Demodulator).

The response time of the complete electromechanical system was sufficient to provide high-speed DP measurements. This system includes not only the pressure diaphragm subsystem and electronics, but also air pressure tubing of large diameter and as short as possible to prevent dampening of the signal (slower response). This sensor tubing did not exceed 1 inch, which required special mounting of the instruments inside protective panels to permit the short tubing runs to the inside and the outside of the building.

All but one of the Validyne sensors measured the difference in pressure between the interior of the enclosure and the exterior barometric pressure. The remaining sensor (PD5) was installed on the internal blast wall to capture the DP impulse effects across that wall.

Absolute pressure transmitters were installed to provide barometric pressure data. They were installed at four strategic points outside the building enclosure to compensate for wind effects. The Omega Model PX4000C0-015A5T meters were set to read a range of 0 to 15 psia (pounds per square inch—absolute). Their 4-20-mA output had a response time of approximately 1 ms. The error is ± 0.25 percent full-scale including linearity, hysteresis, and repeatability. An additional absolute pressure meter (P12) was installed in the furnace room to measure the interior room pressure.

A Foxboro I/A Series Pressure Transmitter, Model IGP20, and accompanying gauge pressure sensor (P11) were installed in the stack of the feed housing unit in the furnace room to measure the pressure in the stack. The transmitter was positioned on the outside of the feed housing with its sensor inside. The sensor has a relatively slow response rate of 20 ms and is accurate to ± 0.07 percent of its span.

Flow Monitoring Equipment

Velocity measurements were used to calculate the flow of air entering the enclosure. The original design included obtaining flow measurements at each damper and at the conveyor belt opening from the feed room to the furnace room.

The installed Dwyer Series 640 Air Velocity Transmitter was ideal for the wide range of flow being measured and included a range setting switch. It has a ± 2 percent accuracy including linearity, hysteresis, and repeatability. The field range was originally set for 0 to 200 feet per minute (fpm) but is now set for 0 to 1,000 fpm. Dwyer air velocity anemometer sensors were installed in the dampers but were subsequently removed when the dampers were sealed tight. Any references to SE-2, F2, SE-3, or F3 in drawings or other areas of this report refer to these two removed anemometers. The signal wiring was abandoned in place and labeled, so they may be used for future instrumentation by TEAD. The remaining airflow velocity transmitter was installed to measure the wind-tunnel effect coming from the feed room, through the conveyor opening, and into the furnace room.

Control and Data Acquisition Equipment

All pressure and flow measurements are transmitted via a 4-20 mA two-wire system from the sensor's transmission device through a signal conditioner to a computer input card for storage, display, and calculations. A personal computer, Dell Dimension 2400 equipped with a peripheral component interconnect (PCI) card receives the measured data and is installed in the freestanding computer-data acquisition control panel located in the Feed Room (see Figure 11).



Figure 11. Monitoring control panel and data acquisition computer.

The monitoring control panel was installed on the east wall of the Feed Room and houses the SLC 5/04, HMI, National Instruments Corporation (NI) input/output (I/O) modules, power supply, and an uninterruptible power supply (UPS) along with the necessary terminal strips. There are ten Hoffman® enclosure boxes with back panels housing various instruments and sensors located at strategic points around the enclosure and furnace. When possible, these boxes were mounted on the outside walls of the enclosure to reduce the effects of heat on the instrumentation.

A 24-volt direct current (DC), 75-watt Peak to Peak Power Supply was installed to provide loop and instrument power. An OmniSmart 1050 UPS was installed to provide uninterrupted power to the computer in case of a power failure. This 1050 volt-ampere line interactive UPS corrects severe brownouts and over-voltages. It maintains 120-volt nominal outputs during brownout.

The NI SCC-C120 two-channel current input modules converts the 4-20 mA current received from the instrument transmitters to voltage by passing it through a 249-ohm resistor. This SCC-C120 is connected to the NI SC2345 low noise connector signal conditioner connector block. This signal conditioner sends the voltage out as a 0 to +5-volt DC signal to the DAS device.

A multifunction I/O board and NI DAS card compatible with the Windows XP operating system was installed in the computer (National Instruments Corporation 2002). The NI PCI-6034E card is used to interface with NI's SCC Modules and sig-

nal conditioner. The E-Series DAS device receives the voltage from the SC2345 using a shielded 68-pin cable (NI type SH68-68-EP cable). The DAS device is an NI PCI-6034E multifunction I/O board and data acquisition (see Figure 12).

In operation, a trigger sets the computer in motion to capture and store the data for each event. The trigger source is a DP measurement that exceeds a set point level. The size of the continuously updated circular data buffer, the speed at which the channel data are acquired, and the amount of scans to be acquired may be adjusted. Data from 16 installed instruments are captured for a 2-second period (commencing 0.5 second before the trigger and ending 1.5 seconds after the trigger). After triggering, the 16 instruments are scanned 2,000 times per second, for a total of 4,000 time-stamped records sent into data storage for each captured event.

At the end of the testing, some 10-second events were captured to provide a larger picture of any soft impulse events resulting from propellant burns. This step was taken to confirm that no significant propellant impulses occurred.

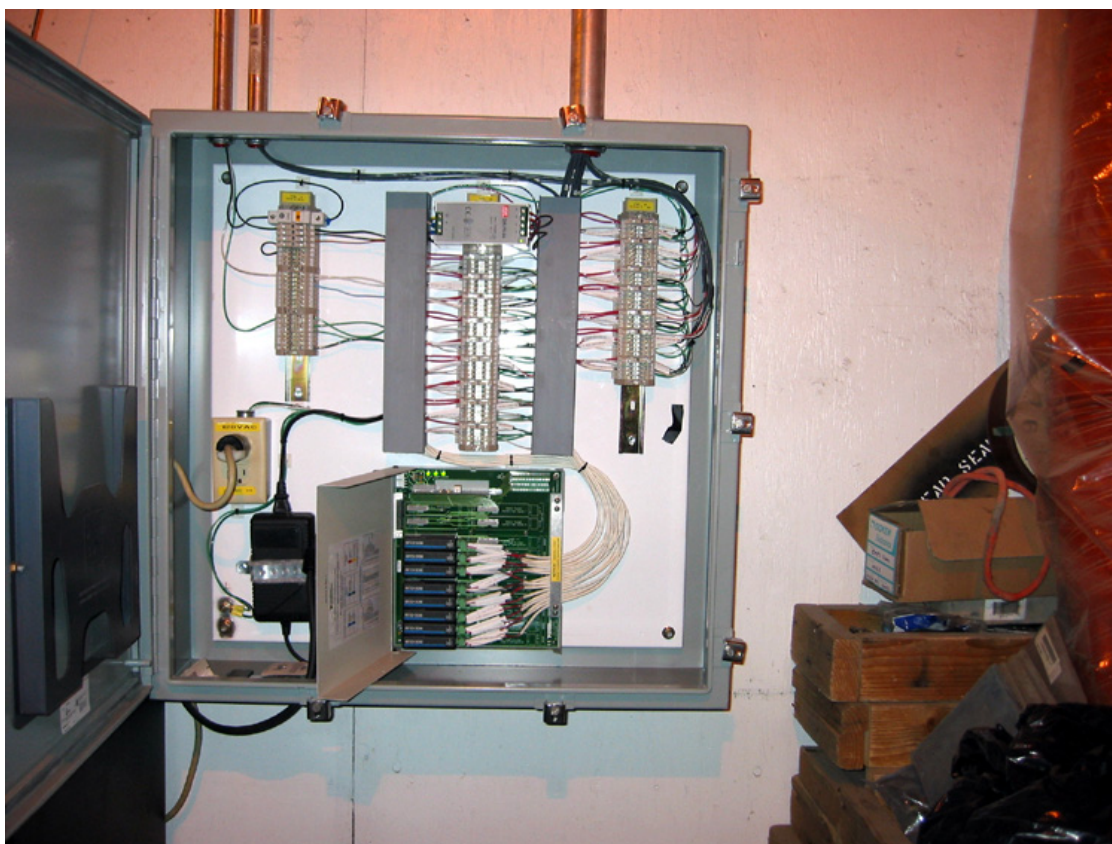


Figure 12. APE 1236 control panel with NI DAS device.

LabVIEW 6.1 graphical developmental software was installed into the computer allowing cost-effective and rapid development of a flexible and scalable test and measurement system (NI 2003). Sensor information may be manipulated into one of several types of graphic formats and compared with each other at the user's discretion. Figure 13 shows a typical display of measured data. The data can be permanently stored on a compact disk (CD) by using the CD-ROM recorder. A Dell A940 printer was installed in the computer-data acquisition control panel to allow color or black and white printing of the measured data.

Software was customized to receive data using the PCI card, to manipulate the data using the LabVIEW computer program to store, display, and print the measured data in various formats. The LabVIEW DAS system was programmed into the computer with adjustable saving parameters and may be used by the operator to display the saved data points in a graphic format. The appendix contains a Condensed Operating Guide furnished to TEAD.

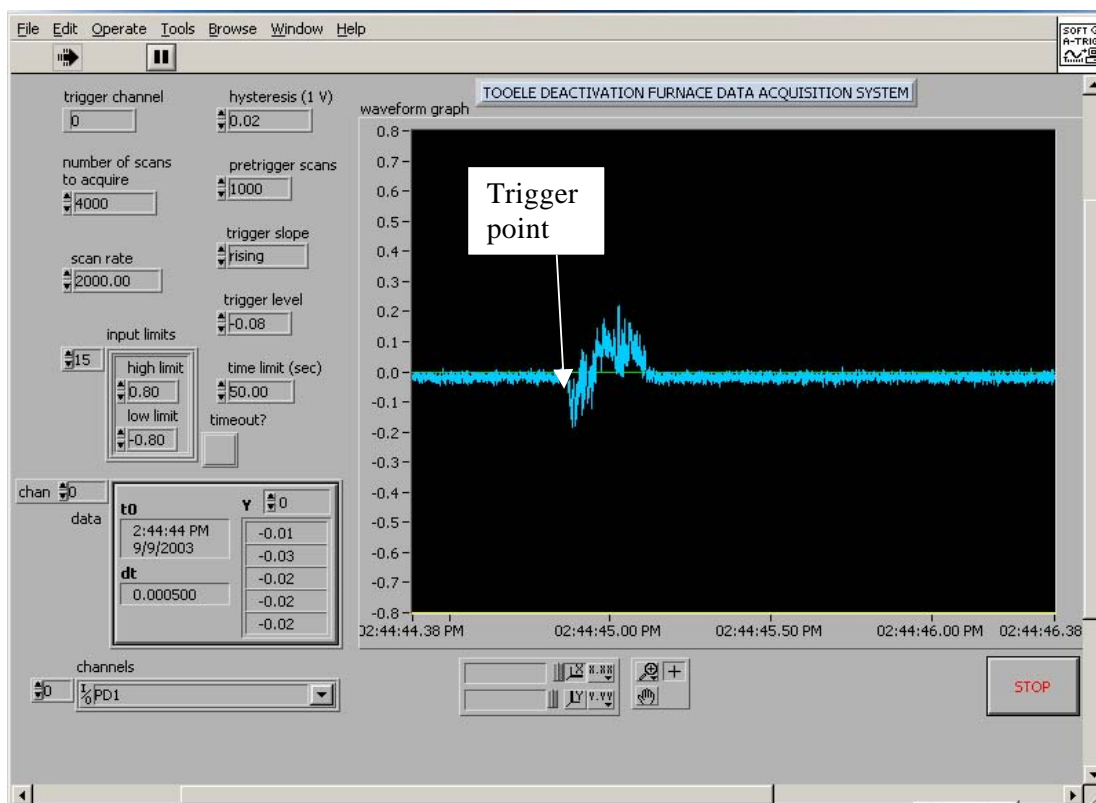


Figure 13. Display of measured data for Channel 0 Instrument PD1.

Instrumentation Layout

Figure 14 shows the locations of the pressure and flow instruments used in the monitoring system. In this figure, circles indicate sensors. A label starting with “P” indicates an absolute pressure sensor, “PD” indicates a DP sensor, and “F” indicates a flow (velocity) sensor. Figures 15–16 show some of the Hoffman enclosure boxes that house sensors. The pressure and flow meters are located in different areas of Building 1320, which houses TEAD’s APE 1236 Deactivation Furnace. The Feed Room, the Furnace Room, and the Discharge Room each has a different configuration as shown in Figure 14 and described below.

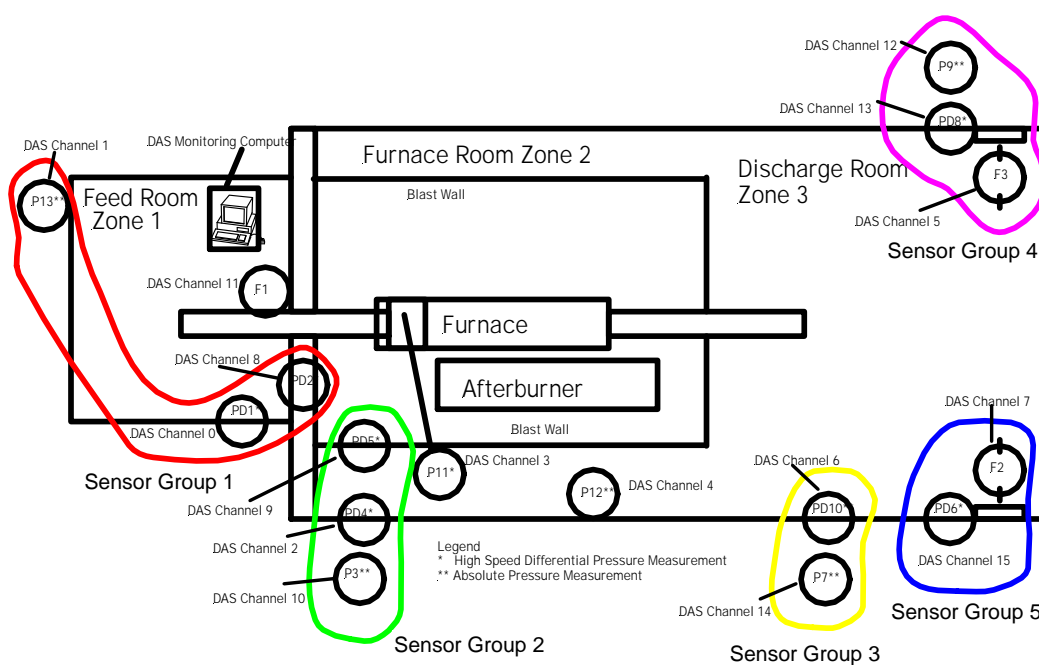


Figure 14. Monitoring system instrumentation layout.



Figure 15. DP pressure transmitter and air velocity transmitter in open panel LP4.



Figure 16. Absolute pressure transmitter, P7 in open panel LP2.

Feed Room

The Feed Room (Figure 17) has two different high-speed DP transducers, an air velocity transmitter, and an absolute pressure transducer.

- PD-2, a Validyne high-speed DP transducer measures the DP between the Feed Room and the Furnace Room. It is displayed on Channel 8 of the DAS. This shows the pressure difference between the Furnace Room and the Feed Room to investigate whether any fugitive emissions may infiltrate the Feed Room.
- PD-1, a Validyne high-speed DP transducer measures the DP between the Feed Room and the outside west wall of the Feed Room. It is displayed on Channel 0 of the DAS. This shows the pressure difference in the Feed Room compared with the ambient barometric pressure and assists in investigating the effects (if any) in the Feed Room from any fugitive emissions.
- F1, SE-1, a Dwyer air velocity transmitter was installed on the south wall opening in the Feed Room. It is displayed on Channel 11 of the DAS. This measures the velocity of air moving through the conveyor belt opening between the Feed Room and the Furnace Room.
- P13, an Omega absolute pressure transducer measures the atmospheric pressure on the exterior north side of the Feed Room. It is displayed on Channel 1. This gives an outside absolute atmospheric pressure in this specific area that may be used in calculations.



Figure 17. Feed Room and APE 1236 Control Panel.

Furnace Room

The Furnace Room (Figure 18) has two different high-speed DP transducers, a gauge pressure meter, and two absolute pressure transducers.

- P11, a Foxboro I/A Series® is a gauge pressure meter on the stack of the feed housing unit in the Furnace Room. It is displayed on Channel 3 and measures the pressure of the furnace feed housing unit.
- PD-5, a Validyne high-speed DP transducer measures the DP between each separate side of the west blast wall in the Furnace Room. It is displayed on Channel 9 of the DAS and reflects the pressure difference between the two blast wall sides to investigate the blast wall's effect on pressure changes.
- PD-4, a Validyne high-speed DP transducer measures the DP between the Furnace Room and the outside west wall of the Furnace Room. It is displayed on Channel 2 of the DAS and reflects the pressure difference in the Furnace Room compared with the ambient pressure and assists in investigating the potential for Furnace Room fugitive emissions.
- P3, an Omega absolute pressure transducer measures the atmospheric pressure on the exterior west side of the Furnace Room. It is displayed on Channel 10 and gives an outside absolute atmospheric pressure on this west side of the Furnace Room that may be used in calculations with other instruments in close proximity.



Figure 18. Furnace Room, APE 1236 Deactivation Furnace.

- P12, an Omega absolute pressure transducer measures the atmospheric pressure in the interior west side of the Furnace Room. It is displayed on Channel 4 and gives an absolute pressure for the Furnace Room area between the afterburner and the exterior wall.

Discharge Room

The Discharge Room has three high-speed DP transducers and two absolute pressure transducers.

- PD-8, a Validyne high-speed DP transducer measures the DP between the Southeast Discharge Room and the outside east wall of the Discharge Room. It is displayed on Channel 13 of the DAS and reflects the pressure difference in the southeast corner of the Discharge Room compared to the ambient pressure in the same area and assists in investigating the propagation of any potential emissions. (Note: this DP monitor was originally designed to reflect the pressure difference through the east damper; however, it was left in place after the damper was permanently sealed.)
- P9, an Omega absolute pressure transducer measures the atmospheric pressure on the exterior east side of the Discharge Room. It is displayed on Channel 12 and gives an outside absolute atmospheric pressure on the east side of the Discharge Room that may be used in calculations with other instruments in close proximity.
- PD-6, a Validyne high-speed DP transducer measures the DP between the Southwest Discharge Room and the outside west wall of the Discharge Room. It is displayed on Channel 15 of the DAS and reflects the pressure difference in the southwest corner of the Discharge Room compared with the ambient pressure, assisting in investigating the propagation of any potential fugitive emissions. (Note: this DP monitor was originally designed to reflect the pressure difference through the west damper; however, it was left in place after the damper was permanently sealed.)
- PD-10, a Validyne high-speed DP transducer measures the DP between the West Discharge Room and the outside west wall of the Discharge Room. It is displayed on Channel 6 of the DAS and reflects the pressure difference in the west side of the Discharge Room compared with the ambient pressure and assists in investigating the propagation of any potential fugitive emissions.
- P7, an Omega absolute pressure transducer measures the atmospheric pressure on the exterior southwest side of the Discharge Room. It is displayed on Channel 14 and gives an outside absolute atmospheric pressure on the west side of the Discharge Room that may be used in calculations with other instruments in close proximity.

4 Testing and Modifications

Testing was conducted to determine the overall pressure in the enclosure during quiescent conditions and the amplitude of the pressure fluctuations during demilitarization. It is assumed that, if the enclosure can be maintained with a negative pressure, even during detonations, the fugitive emissions will not escape the enclosure and compliance would be assured. Modifications were made to the enclosure after each testing period to help achieve compliance.

Monitoring Test 1

Testing was performed the week of 16 October 2003 to determine which DP sensor was the best trigger source. Before the test, the deactivation furnace was started and the monitoring system was operated to fine-tune the settings and to determine the performance of the installed system.

During testing, 20-mm electric-primed cartridge-type M55A2 munitions were fed into the APE 1236 Deactivation Furnace (U.S. Army 1994). PD5, the sensor measuring the DP between the two sides of the blast wall, was chosen as the trigger source because of its higher pressure impulse and quick response rate due to its proximity to the kiln. The set points were adjusted in the computer to trigger on higher blasts in an attempt to capture some of the worst-case pressure events. At each triggered event, the captured data for a 2-second-acquisition period was saved to the computer's hard disk in a spreadsheet-compatible format for later analysis. The trigger level from PD5 was varied from -0.40 to -0.70 in.w.c; -0.65 in.w.c. appeared to be optimal for capturing the larger excursions.

Tables 1 and 2 outline Monitoring Test 1 normal operating variables for temperatures and pressures. Table 3 lists the data acquisition system parameters used.

Table 1. Monitoring Test 1 operating temperatures.

	Required	Actual
Kiln burner end	>45 °F	>82 °F
Kiln feed end	344 °F	355 °F
Afterburner	1579 °F	1633 °F
Baghouse inlet duct	748 °F	795 °F
Baghouse outlet duct	389 °F	410 °F

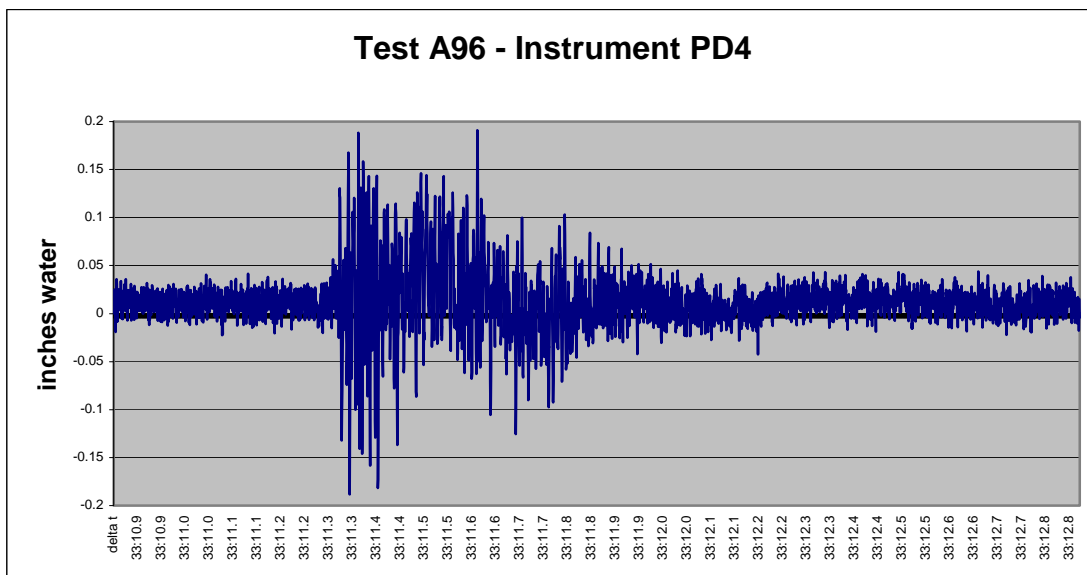
Table 2. Monitoring Test 1 operating pressure.

Pressures	Required	Actual
Feed end draft	-.24 in.w.c.	-.24 in.w.c.
System draft	-1.2 in.w.c.	-1.2 in.w.c.
Baghouse differential	4.7 in.w.c.	5.3 in.w.c.

Table 3. Data acquisition parameters for Test 1.

Parameter	Setting
Scan (sample) Rate	2,000 = 2 seconds
Scans to Acquire	4000
Pre-trigger Scans	1000
Hysteresis	0.01
Trigger Slope	falling
Trigger Level	-0.40 to -0.70 in.w.c

The normal enclosure pressure at most of the sensor locations within the enclosure was at a slightly positive but close-to-zero pressure. It was noted that the internal building pressure fluctuated significantly as expected due to doors opening and wind gusts. The DP sensing instruments were effective in capturing the quick detonations, thus reflecting the pressure propagation within the enclosure. The extreme positive pressure fluctuations resulting from a detonation briefly caused a pressure increase less than +0.6 in.w.c., and the nominal high pressure was closer to +0.25 in.w.c. Figure 20 shows an example of a triggered event (detonation). The slightly positive average pressure can be observed in the figure.

**Figure 19. Typical pressure chart from detonation at PD4, Test 1, A96.**

Rapid positive/negative oscillation at the building wall indicates that fugitive emissions would have a difficult time escaping the enclosure, even without providing a recommended negative pressure within the enclosure. It is probable that, if a minute quantity of contaminated air gets blown out of a building crack, most of it would likely get sucked back in immediately as the pressure swings in the other direction once the detonation is finished. Even though Test 1 revealed that the interior of the enclosure was not operating under negative pressure, the major design is based on the enclosure being under a vacuum. The test data indicate that the average DP under quiescent conditions is nearly zero as measured by instruments at the opposite ends of the enclosure, PD4 (north end of the furnace room) and PD10 (south end of the discharge room). Table 4 shows average DP for quiescent conditions.

Table 4. Test 1 – Average quiescent DPs for PD4 and PD10.

Test #1	Average Quiescent DP (in.w.c.)	
	PD4	PD10
A49	0.0117	-0.0048
A64	0.0091	-0.0092
A85	0.0098	-0.0080
A92	0.0011	-0.0041
A104	0.0094	-0.0063
Average	0.0082	-0.0065
Total average: 0.0009, approximately zero.		

It is highly likely that the lack of negative pressure is the result of air leakage at many locations in the unsealed metal building. Therefore, the recommendation was to seal the enclosure for leaks and conduct further testing to ensure that proper negative pressure can be sustained during demilitarization. To maintain negative pressure in the enclosure, even during the largest worst-case detonations, the pressure would need to be reduced by -0.6 in.w.c. This recommendation assumes that future feedstock would be no more energetic than that used during testing. Unfortunately, the likelihood of achieving a pressure drop of this magnitude is improbable without major alterations to the enclosure type and design. Therefore, a pressure as negative as possible without major building renovation became the goal.

Instruments PD4 and PD10 measured the DP between the inside and outside of the wall in the furnace area and the discharge area, respectively. During testing, these measurements were recorded to the data acquisition computer every 500 microseconds. The response time of PD4 and PD10 were designed to be approximately 500 microseconds. Considering the Nyquist criteria, which require that the sample rate be twice as fast as the fastest signal of interest, the system can resolve frequencies to 1,000 hertz (Hz), which should be within the requirements for analysis of the detonation pressure impulses on the enclosure wall.

Of interest is the pressure ringing, or oscillatory behavior, that occurs inside the enclosure as a result of the detonations (see Figure 21).

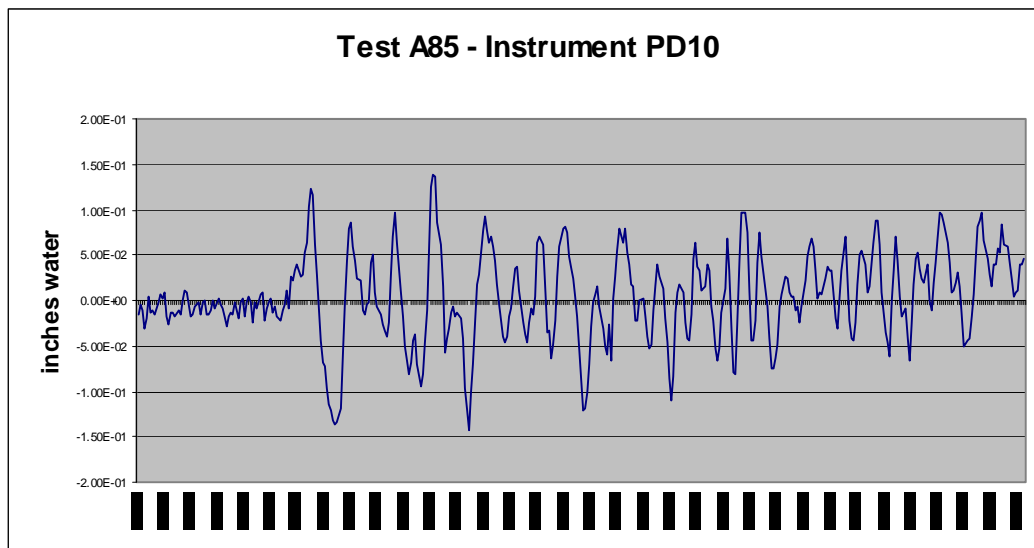


Figure 20. Oscillatory pressure behavior for PD10, Test 1, A85.

PD4 and PD10, which are on the west side of the building, show a pronounced 200 Hz, with lesser 160- and 50-Hz components, as determined by the DP range for the event; see Figure 21 and as displayed in Figure 22.

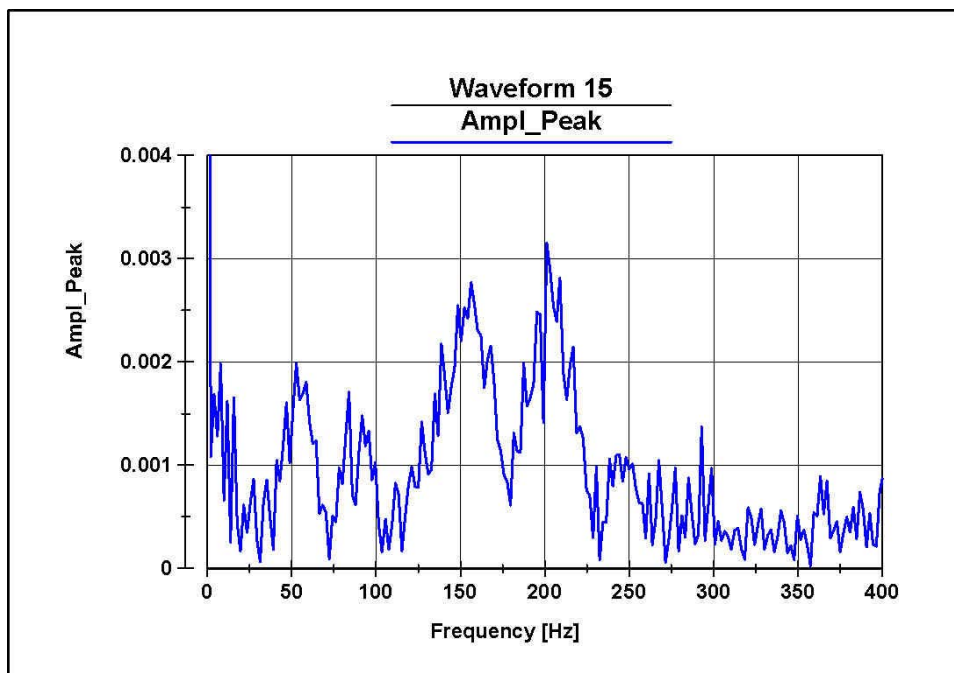


Figure 21. Oscillatory pressure versus frequency for PD10, Test 1, A85.

Enclosure Sealing Modification

Sealing involved applying spray-on polyurethane foam to the inside of the enclosure. Because the building surface temperature might reach close to 150 °F, creating a problem for most polyurethane foam sprays, a thermal sealant was applied to tolerate the high temperature. The objective of using thermal sealants was to seal the air leaks while minimizing thermal insulation. Additional insulation would cause increased interior heat buildup.

A professional insulation installer sprayed a thin layer of foam insulation, approximately 0.5-inch thick, on all seams, opening cracks, crevices, and holes to obtain a thin seal. No insulation was applied if it was not necessary. Patches were placed over some of the larger holes before sealing. A curing time was allowed for the foam before an overcoat thermal barrier of no more than 0.75-inch thickness was applied. This was applied only over the foam insulation and to adjacent areas as needed to provide a bond.

Monitoring Test 2

After the new sealant was applied and cured, testing during operational activity was performed to test wind effects on and accuracy of the DP sensors, and to determine whether covering openings in the enclosure could significantly impact the pressure. These tests took place the week of 17 February 2004.

The wind test was conducted on a day that the wind was steady. A filter was built in the field by attaching 6-ft-long plastic tubing, partially filled with steel wool, to the outdoor DP sensor PD4. PD4 was chosen because it was located in a position affected by wind. Comparison of the pre-filter DP readings with the post-filter readings indicated that the winds did not noticeably affect the DP sensor readings.

A comparison of the electronic pressure readings to an incline manometer was performed to provide added confirmation that the electronic instrument readings were accurate. An incline manometer was set up with a pressure tap approximately halfway between PD4 and PD10. Comparing the readings of the incline manometer (-0.036 in.w.c.) to the average readings taken from PD4 (-0.027 in.w.c.) and PD10 (-0.05 in.w.c.) suggest that the readings are accurate.

Tests were then performed prior to feeding ammunition to compare pressures before and after covering different openings in the building to determine the associated pressure change. A baseline pressure reading was taken, then different parts of the enclosure were systematically sealed, and the difference in pressure was monitored.

Plastic sheeting and duct tape were used to provide an airtight seal in a quick, easy manner that could be removed rapidly (see Figures 23 and 24). The results in Table 5 show that a substantial difference in pressure resulted from sealing the main overhead door and both dampers. Covering additional openings would create safety issues (i.e., sealing the man-doors); and the pressure difference improvement from such measures is small enough to not warrant the actions. Table 5 compares measurements from two DP sensors, PD4 and PD10, during testing. These results indicate that covering the door and dampers is a practical solution to lowering the pressure.



Figure 22. Overhead door covered with plastic sheeting for testing.



Figure 23. Damper covered with plastic sheeting for testing.

Table 5. Monitoring Test 2 results for temporary covering of openings.

	No openings covered (in.w.c.)	Main overhead door covered (in.w.c.)	Main overhead door and both dampers covered (in.w.c.)	Main overhead door, both dampers, and both west man-doors covered (in.w.c.)	Main overhead door, both dampers, and all other doors covered (in.w.c.)
PD4	0.01	-0.027	-0.04	-0.05	-0.05
PD10	0 in	-0.05	-0.052	-0.065	-0.07
All pressures were taken after the enclosure was sealed with the spray foam insulation.					

Compliance Testing

Compliance testing was performed from 31 March through 5 April 2004 at the APE 1236 furnace. These tests monitored air emissions from the furnace system while burning propellant, explosive, and pyrotechnic materials. Pressure monitoring was performed from 31 March through 3 April 2004. TEAD requested that the large overhead door and the dampers be sealed for this testing. To create seals fast enough to meet the testing schedule, the overhead door and dampers were temporarily sealed by duct-taping large sheets of plastic over the outside of the door and dampers as done previously for Monitoring Test 2.

A manometer was set up to read the DP in the furnace room compared with the barometric pressure. This comparison gave a secondary, manual validation of the DP readings recorded in the LabVIEW program on the DAS.

Channel PD5, reading the DP between the furnace room inner blast wall and outside blast wall, was again used as the trigger for receiving the detonation blasts. Table 6 summarizes the wind velocity, manometer pressure reading of the furnace room, and the ordnance feed.

Table 6. Compliance testing – wind velocity, pressure, and ordnance feed.

Test	Test Date	Test Time	Approx. Wind Velocity (mph)	Manometer Reading in Furnace Room, (in.w.c.)	Feed Ordnance
E	3/29/2004				20mm cartridges (M5643, LC-84G241-078, RN084A005-012M56A4), high explosive incendiary, single round, DODIC: A890
F	3/30/2004	9:13AM	20, North	+0.15	To set up the system: 20 mm cartridges, DOP-72-3 incendiary M96. At 11:15AM propellant with 5.33 grams of calcium hypochlorite, Ca(OCl) ₂ (approx. 60 mL of water was added to the propellant to slow the burn rate agent)
G	3/31/2004	12:00PM	37	-0.02 to -0.08	20mm cartridges, KOP-72-3 incendiary M96 rounds plus 11.33 grams of HCB* at feed rate of 8 units/30s
H	3/31/2004	6:20PM	14	-0.15 to -0.2	Propellant at rate of one/15s including 60mL water in each; one propellant with high test hypochlorite, the next propellant without, etc.
I	4/1/2004	8:00AM	5.5	-0.05 to -0.09	20mm cartridges, KOP-72-3 incendiary M96 rounds plus 11.33 grams of HCB at feed rate of 8 units/30s
J	4/1/2004	2:03PM	6	-0.15	Propellant at rate of one unit/15s including 60mL water in each; one propellant with high test hypochlorite, the next propellant without, etc.
K	4/2/2004	9:08PM	4.5, South	-0.07 to -0.05	20mm cartridges, KOP-72-3 incendiary M96 rounds plus 11.33 grams of HCB at feed rate of 8 units/30s
L	4/2/2004	3:22PM	17, NW	-0.02 to -0.15	20mm cartridges, KOP-72-3 incendiary M96 rounds plus 11.33 grams of HCB at feed rate of 8 units/30s
M	4/3/2004	7:50AM	2, South	-0.13	6 packages of 5.56 mm tracers every 20 s. M196 20mm cartridges, KOP-72-3 incendiary M96 rounds plus 11.33 grams of HCB at feed rate of 8 units/30s

*HCB = hexachlorabenzene

During Test F on 30 March 2004, wind caused the plastic cover on the damper on the east side to depress, and simultaneously caused the plastic cover on the damper on the west side to billow out. It appears to have created a slight positive pressure on one side of the room interior and a slight negative pressure effect on the opposite side. The data displayed on the graph in Figure 25 show the wind effects for one of the more extreme cases during the compliance testing and does not reflect any detonation measurements. The wind velocity during Test F averaged approximately 20 miles per hour (mph).

Propellants were burned during Test J on 1 April 2004. A number of data sets during this test were reviewed, each containing 20,000 samples (10-second duration). No notable large visual fluctuations were evident during burning of the propellant pack. It was difficult to get a trigger on anything that did not appear to be just normal fluctuations. A negative pressure condition was maintained while burning propellants.

Figure 26 shows a typical triggered event during Test K. Even though instantaneous impulses produce a positive reading, the average pressure is below negative, indicating that the enclosure is operating in a slight vacuum. A comparison between Figures 26 and 20 shows that sealing the enclosure and covering the large overhead door and dampers brought the average pressure below zero. For any 2-second period during these tests, the average enclosure pressure stayed negative.

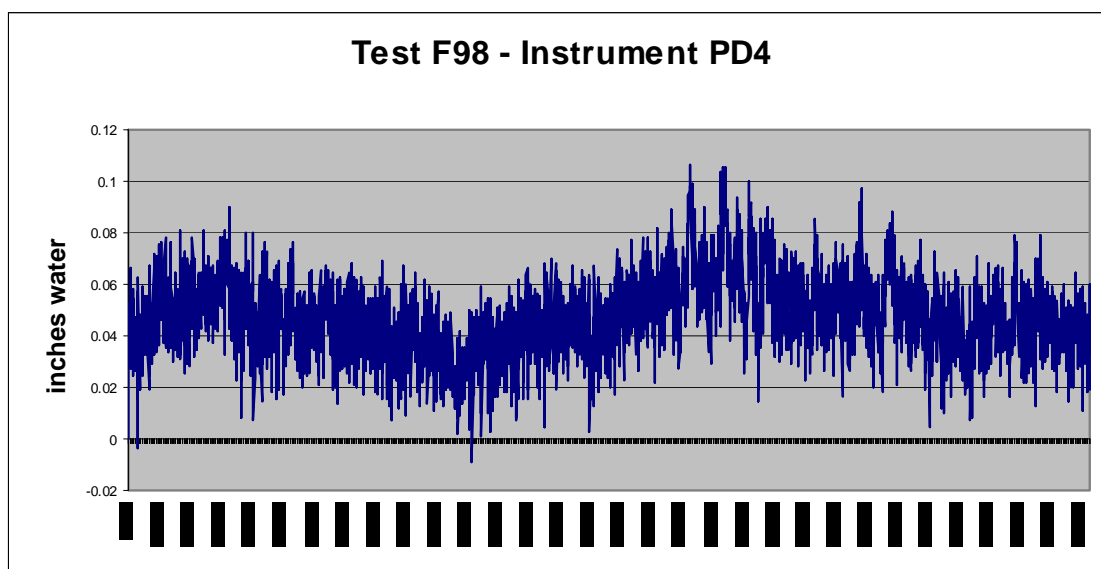


Figure 24. Wind effects on building pressure as sensed by PD4.

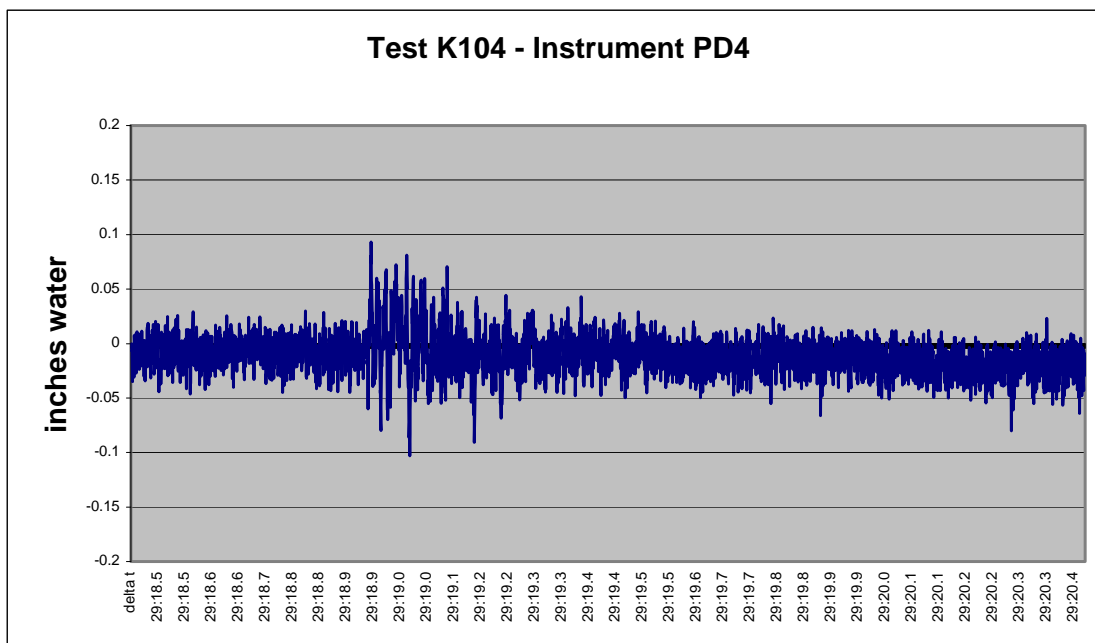


Figure 25. Sample PD4 pressure readings during compliance testing – after the overhead door and dampers were covered.

The U.S. Environmental Protection Agency (EPA) sent a recommendation to TEAD environmental personnel in June 2004 stating that they would allow a 5-second delay for any pressure drop across the kiln if TEAD agreed to seal the large overhead door and dampers. Resource Conservation and Recovery Act (RCRA) requirement allows a 15-second delay (Woodworth 2004). TEAD chose to seal the overhead door and the dampers permanently in accordance with the EPA recommendation.

Final Sealing Modifications

It was determined that the existing overhead door would need to be replaced because it could not be sealed without permanently closing it and securing the gaps. An industrial door designed to withstand high temperatures and maintain a nearly airtight seal was chosen (M&I Re-Coil-Away). The seal and guide system on this door allows for total structural integrity in negative pressures and high wind loads of up to 88 mph (Albany Door Systems 2004). The old overhead door was removed, and the south wall of the enclosure was modified to accommodate the new overhead door. Both dampers were covered and sealed tight with matching steel siding. Foam insulation sealant was sprayed on the seams of all openings to provide the near airtight environment.

Long-Term Operation

It is recommended that TEAD maintain the enclosure by regularly plugging any new holes punched into the enclosure by flying shrapnel from the detonations in the furnace. Clear silicon should not be used for plugging holes because a primary method to detect holes is to turn the lights off in the enclosure and look around in the darkness of the building interior for light shining through.

Periodic data gathering using the monitoring system during future deactivation operations will allow TEAD to monitor their operations to determine if there are any significant changes in pressure. This will also give TEAD a database to present to EPA/RCRA for future discussion.

After more than 1 year of deactivation operations with the fugitive emission enclosure, only one operational issue has arisen. Due to the high temperatures inside the enclosure, the electronics associated with the rotation sensors for the furnace have failed. The original proximity sensors have since been replaced with optical sensors. This change seems to have mitigated the problem. The current electronics are rated for 180 °F.

5 Summary and Conclusions

Tooele Army Depot operates a rotary kiln APE 1236 ammunition deactivation furnace that is regulated under hazardous waste and air regulations. During operations, fugitive emissions from detonations of ammunition within the furnace may escape through openings. If these emissions are not controlled, the furnace may fall out of compliance with the fugitive emissions requirements of the associated regulations and not be allowed to operate.

An enclosure was constructed over the feed, furnace, and discharge areas to contain fugitive emissions long enough to be pulled back into the air pollution control system. A monitoring system was designed and installed to assist in determining the effectiveness of the enclosure. The system measures, records, and analyzes the effects of pressure fluctuations and airflows at the enclosure walls.

The monitoring system design includes high-speed DP sensing instrumentation at predetermined locations installed in the enclosure. Six high-speed sensors measure the difference in pressure between the interior and exterior of the enclosure; and one sensor measures the DP between both sides of the blast wall. Detonation propagation during trial burns can be monitored and recorded by these pressure differences. Meters at four points along the outside of the building enclosure also measure absolute pressures. These different points allow comparisons of the wind effects. Flow velocity anemometers were placed in each damper and in the flow opening between the feed and furnace rooms.

A detonation is detected by the DP sensor located on the blast wall. During a detonation (or triggered event) data are captured for a 2-second period and recorded on the control computer hard disk in spreadsheet-compatible format for later analysis. The system was shown to be effective in capturing the quick detonations and reflecting the pressure propagation through the recorded data.

Preliminary testing indicated that the containment enclosure was not operating under consistent negative pressure due to numerous openings in the enclosure walls. The interior of the enclosure was sealed with sprayed polyurethane foam and a thermal barrier sealant. Further testing showed that the interior was very close to a zero DP but positive. Covering the large overhead door and dampers against air leaks brought the enclosure to a slightly negative pressure. EPA agreed to allow for

a 5-second delay if the openings were sealed. TEAD installed a new sealing overhead door and sealed the dampers, allowing them to meet both EPA and RCRA's requirements for continued operation. Therefore, this technology application met the exit criterion of meeting the fugitive emission requirement of the HWC NESHAP and was accepted by the respective state regulatory agency.

One operational issue has arisen since the enclosure has been used during operation: the rotation sensor electronics have occasionally failed because of the higher interior temperature. The original proximity sensors have been replaced by optical sensors, which have proven more reliable.

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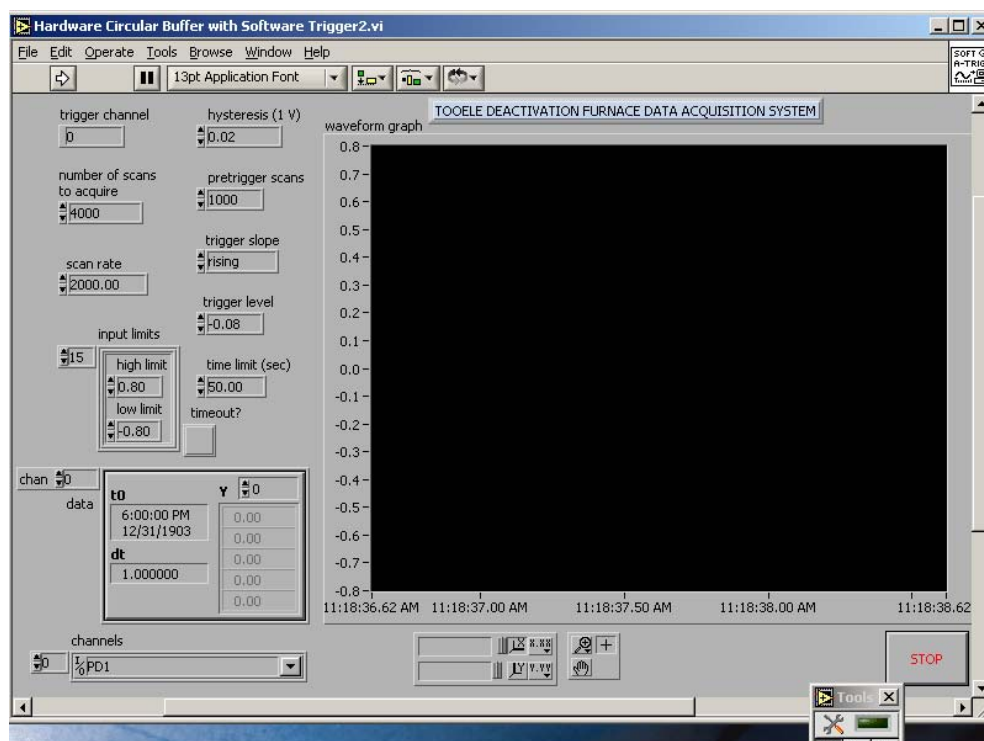
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Appendix

Condensed Operating Guide for the Tooel Deactivation Furnace Data Acquisition System (DAS)

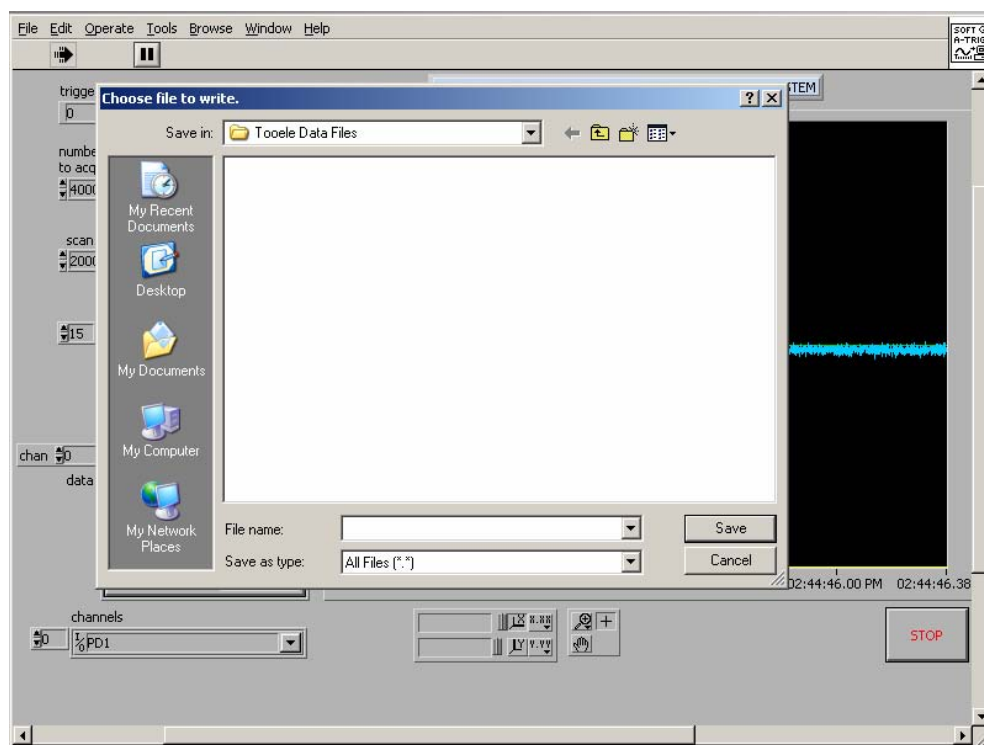
1. On the Windows XT desktop, click on the LabVIEW icon. Click on “Open VI” button in the LabVIEW window. In the “Tooel Applications Files” subdirectory, load the “Hardware Circular Buffer With Software Trigger2.vi” application.
2. When the screen below appears, delete the “trigger channel” value and insert the desired channel number required for initiating the data snapshot. The cross-reference guide for the trigger channel numbers for each instrument is shown in the attachment.



3. On the screen above, note the three adjustable values for “number of scans to acquire,” “scan rate,” and “pretrigger scans.” These values are used to set up the circular buffer parameters. Use them to set the size of the continuously updated circular data buffer as “number of scans,” how

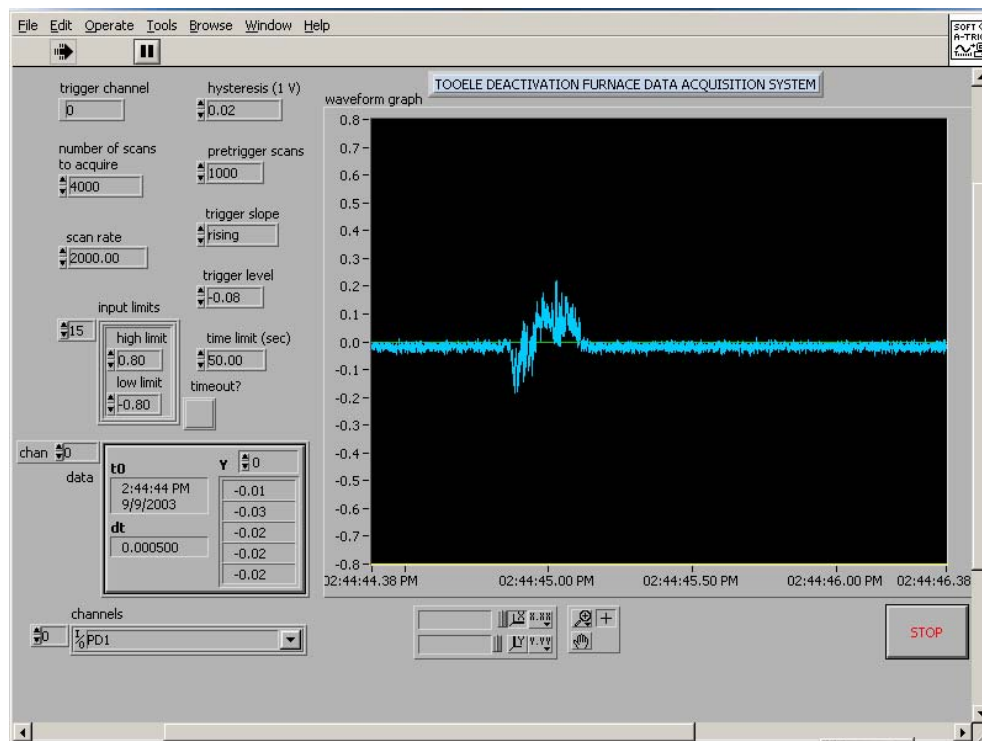
fast the channel data is acquired in the buffer as “scan rate,” and the number of “pretrigger scans” to acquire and display before the triggering event. Use the arrows to click in the desired values before running the DAS.

4. Also note on the screen that the “trigger level” is adjustable in the same manner as above. You can also set the trigger slope as positive or negative using the “trigger slope” adjustment.
5. “Time limit” value is number of seconds the DAS will run, and is provided to allow the DAS to stop scanning and looking for triggering events. Normally this value is set to allow a time window for the DAS to look for events, so as not to fill the hard drive with useless data as it would if it were running continuously. To let it run continuously, insert a very high value in this field.
6. Note the right facing arrow in the upper left of the DAS screen. When all parameters are set as desired, click this arrow to start the circular buffer to look for triggering events. If it detects a trigger event as defined, it will pop up a save file screen as shown below.

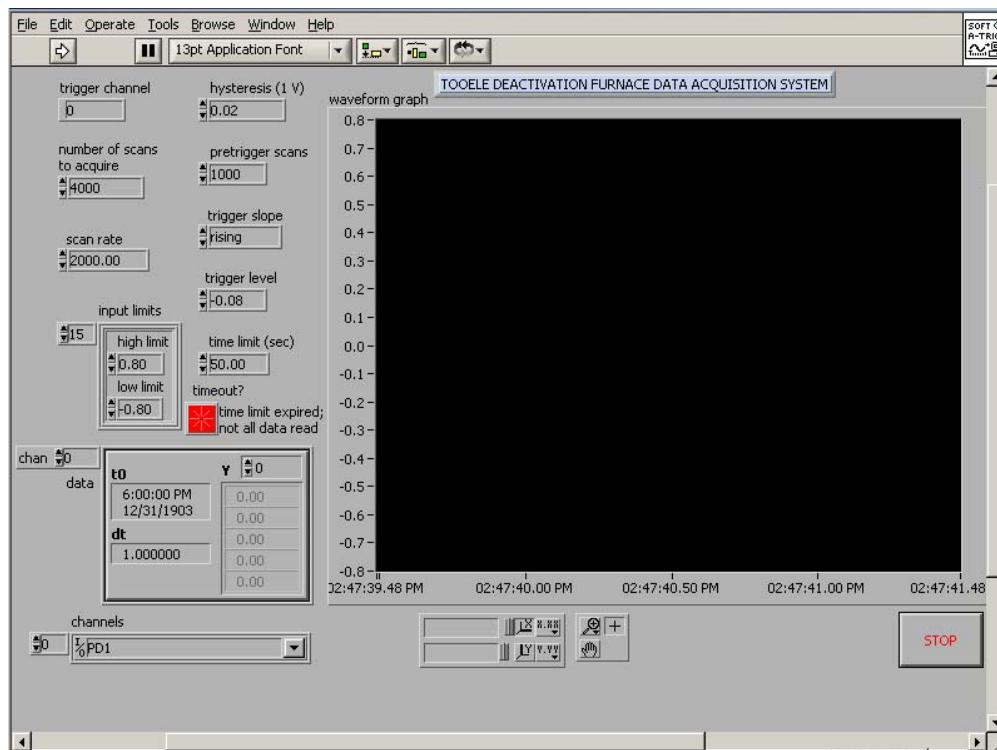


7. Check to see that the save directory is “Tooele Data Files,” enter the desired file name, and click save. This will save scans for all 16 channels into an EXCEL-compatible file format for future analysis and comparison. EXCEL was chosen for primary analysis because the data manipulation and charting tools are quite powerful, and many people are familiar with it. Other powerful tools are available in LabVIEW to manipulate the data more directly (e.g., filtering). Contact MSE Technology Applications, Inc. if these advanced tools are needed.

8. The screen will then look similar to the one shown below, which is a chart of the captured event that was saved.



9. The DAS will continue to look for another trigger event until it times out and the “timeout” light turns red as shown in the following screen shot. If another trigger event occurs before timeout, it will pop up another save file window as described in step 7.



10. Press the “timeout” button, and you are ready to readjust the parameters and restart the DAS using the arrow button.

MSE desires to provide Tooele Army Depot deactivation furnace with a DAS that is effective in providing data and analysis in support of compliance with the new Federal NESHAP Maximum Achievable Control Technology (MACT) Standards. For questions, comments, or suggestions contact Don Schiller, MSE-TA, 406-494-7303, resdjs@mse-ta.com. Additional information and system description for the DAS is provided in the design review document, which is available by e-mail request at the above address.

Attachment to

Condensed Operating Guide

for

Tooele Deactivation Furnace Data Acquisition System (DAS)

